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reference to the function of mediation. All may be known mediately; but to know them mediately is only an indirect way of knowing them immediately. This is as true of a mathematical triangle, which is mediately known by means of these words, as of color, life, or anything else. When corrected in the light of these considerations, the realistic anti-intellectualism of James escapes the verbalism and abstractionism of "vicious intellectualism," without that discrediting of analysis and lapse into uncritical intuition—that dissolution of order into chaos, which marks an even more vicious immediatism.

RALPH BARTON PERRY.

HARVARD UNIVERSITY.

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### PHILOSOPHY AND THE FLATFISH

THERE has recently appeared a monograph<sup>1</sup> by Francis B. Sumner, of the United States Fisheries Laboratory at Woods Hole, Massachusetts, which contains a number of facts important to all philosophers who are endeavoring to construct a new world-view. There are two reasons why these facts should be here reported and discussed: first, zoologists, under whose eyes alone the monograph is likely to fall, are unfortunately not interested in the philosophical implications of their *own* researches; and, secondly, philosophers mostly refrain from analyzing such *very* empirical matters as, say, the behavior of the flatfish, and distrust every other philosopher who dares wander so far from his own bailiwick, which is supposed to include little more than "pure logic" and "pure experiences." The consequence of this mutual aloofness is that most philosophers are very wretched biologists and most biologists no less wretched philosophers. When, therefore, a fact is brought to light which is absolutely unequivocal and empirically demonstrated and laden with implications about the nature of organic adjustments, percepts, and the perceiving process, it should be proclaimed.

Such a fact is found in Sumner's study. It interests me peculiarly because it completely confirms, by experimentation, the central point of my conclusions about the retinal image and the imitative reflex.<sup>2</sup> My own inferences were reached by an analysis of a few somewhat obscure psychological events. In order to follow the analysis, the reader had to observe those events with severe accuracy;

<sup>1</sup> "The Adjustment of Flatfishes to Various Backgrounds," *Journal of Experimental Zoology*, Vol. X., No. 4.

<sup>2</sup> This JOURNAL, Vol. VII., pp. 92 and 204. The second of these papers was read, in part, before the American Philosophical Association, December, 1909.

but this seems to have been not at all easy, if I may judge from what few comments were passed on them. In Sumner's data, though, no such difficulty arises. Anybody can grasp them readily, and some of their implications force themselves upon whomsoever is at all familiar with the problems centering around perception. I need hardly say that these implications have not been drawn by Sumner.

The flatfish, like many other varieties, changes its hue to conform to the color of the backgrounds on which the creature happens to lie. For a time biologists supposed that this adaptation was effected by some direct photochemism—*i. e.*, by action of light upon the skin. But, a quarter century ago, Pouchet proved that it was brought about through the functioning of the eye. He found that blinded fish do not change their color adaptively. Interesting and significant as this discovery is, however, it does not tell us anything about the most astounding behavior of the flatfish, namely, its adaptation of its own geometrical skin-patterns to copy the geometrical pattern of the sea-bottom upon which it rests. By one of those freaks of circumstance which are only too common in all scientific fields, nobody paid serious attention to this phenomenon until Sumner approached it last year, first at the Naples aquarium and later at Woods Hole. "In observing a turbot," says Sumner, "I was impressed by the detailed resemblance which obtained between the markings of the skin and the appearance of the gravel on which the fish rested. . . . The query at once suggested itself: Is it a mere coincidence, or does the fish have the power of controlling the color *pattern* as well as the general color *tone* of the body?"

To answer this, Sumner prepared a number of backgrounds, some reproducing various types of natural sea-bottom (fine sand, coarse sand, fine gravel, coarse gravel, of various colors), and some being highly unnatural geometrical patterns (checkerboard, polka dot, stripes, screen, etc.). Placed in a tank having one of these patterns on its bottom, the flatfish began to copy the pattern *on its back*. ("Copying" does not imply "consciousness" or "effort," so far as the mere use of the word here is concerned.) The time required to complete the imitation varied.

This time ranged from a few seconds to several days. A change involving the almost complete withdrawal from view of the skin pigments in a dark specimen probably required the longest period. In general, . . . the maximum effect was commonly attained within one or two days at the most. The fact . . . that practise or habituation to these changes greatly reduces the time required was clearly shown. . . . Certain specimens, after several changes of background, were found to adapt themselves, in almost full measure, to one of these within a fraction of a minute.

The reader can not be asked to believe that some of the adaptations were so perfect that, in photographs, the flatfish is all but indistinguishable from the background; or that the spots on the skin became smaller when the diameter of spots on the background was reduced by less than a centimeter. To appreciate this, he must inspect the photographs appended to the monograph. Naturally, the imitation was by no means equally successful against all backgrounds. "Fixed morphological conditions" prevented the reproduction of perfect squares, triangles, circles, etc. It was, however, so exceedingly plastic and sensitive that "the notion that the fish is limited to a few stereotyped responses, representing the most familiar types of habitat, must be rejected at once."

The discoveries of greatest interest to the psychologist and the philosopher are still to be told. They are two: *first, the imitation is accomplished through the flatfish's eyes; and, secondly, only a part of the fish's visual field is involved in the process—the creature does not imitate everything it sees.* The first discovery might have been made by pure analysis. For, were the eye not the instrument of imitation, then we should have to assume that the light reflected up from the background acted directly on the skin. Against this, however, there are two objections: first, the flatfish's belly, which directly receives the reflected light, is *not* sensitive—*only the back, turned away from the reflected light*, takes on the patterns; and, secondly, as Sumner points out, "it is impossible to see how responses to a *pattern* could be brought about through any organs except the eyes, for these alone are provided with the lenses necessary for the production of images." The reader who suspects the analytical method, however, may ignore these proofs.<sup>3</sup> For Sumner has demonstrated the matter by cauterizing the flatfish's eyes with silver nitrate, blindfolding them, or blinding them completely. So treated, the animal ceased altogether to imitate the background pattern, and its hue reverted to an even, dark shade "representing more nearly the resting state of the chromatophores."

The second discovery grew out of a series of experiments in which the walls of the tank were variously colored and patterned.

In the case of the *Rhomboidichthys*, . . . that part of the bottom immediately surrounding the fish appeared to be the one chiefly effective. . . . The influence of the vertical walls of the vessel commonly seemed to be a subordinate one, *even in cases where the fish was so large that it covered a considerable frac-*

<sup>3</sup> The possibility that tactile stimuli may produce the effect can not be absolutely eliminated by pure analysis. Sumner has put it out of court, though, by the simple experiment of putting fish on glass bottoms, the under side of which was painted with patterns. The imitative reaction was *exactly as quick and as sure as ever*.

tion of the bottom and was obliged to lie constantly with its eyes close to one side or another of the jar. . . . What the fish saw directly overhead . . . seemed to exert a negligible influence upon the color pattern.

So much for the chief facts. Let us now consider their bearings upon the problem of space perception. Be it noted, first of all, that the imitative reaction is not seen by the flatfish—or at least only partially—and that Sumner has shown that the animal can adapt while its entire body (except for the eyes) is buried in sand or completely masked with a cloth or deeply stained. This renders it “highly improbable that any direct visual comparison on the part of the fish between its own body surface and the surrounding background is an essential factor in the production of these changes” (p. 470). In other words, “consciousness” (*in whatever sense the term be used*) *is not an instrument in making one space pattern match another*. If it is not, how can anybody continue to hold the old psychological doctrine that the arrangement of space-elements (or non-spatial-elements) into forms, patterns, or perspective orders is brought about in any degree by the cognitive process, or by the “association of ideas”? As with the imitative reflex among human beings, so here. The process is set up by a physical stimulus, and its result either can not or need not be perceived by the organism. *The correspondence, therefore, is not between the flatfish’s percept A and the same flatfish’s percept B; it is between a stimulus (which may or may not be perceived, for aught we yet know) and a chemical pattern which is the cause of a perception in an external observer*. In other words, the flatfish is not imitating merely its own percept A, but is doing so in such a manner that *some other creature will perceive the flatfish’s skin as having, not merely the characteristics of the fish’s percept A, but as having the characteristics of the external cause of perceiving A*. To make this last point clear, I must call attention to a highly significant fact which biologists have overlooked.

The flatfish’s eyes are very close to the sea-bottom, sometimes only a centimeter or so above it—as when it buries its body. It is while in this position that the eyes sense the shape, size, color, and arrangement of the sand and pebbles. These objects are therefore cast upon the retina in an extremely oblique perspective. You may get the general effect by holding your eye close to your desk and glancing across the latter. The foreshortening will be at a maximum; a few items in the foreground will loom up, while the converging of the rest of the field will be rapid. But this is not the scene which the flatfish reproduces on its skin. It depicts, with its chromatophores, the color, shape, size, and pattern of the material on the sea-bottom *as this material would appear to an eye whose line of direct vision*

*was perpendicular to the plane of the sea-bottom and at a great enough distance from the sea-bottom so that the units of the pattern could be seen without any appreciable perspective distortion.* Roughly speaking, the skin pattern closely resembles that of the sea-bottom as the latter would appear to you if you were looking directly down at it, and six inches or more away from it.

However this queer deed is accomplished, it certainly *results* in a translation of one perspective into another perspective; and *this translation is precisely that which is deducible from Euclidean space.* The rate of reduction of relative sizes in the first perspective is a function (mathematical) of the distance between eye and plane; and this very same relation governs the chemisms in the chromatophores and also the rearranging of the latter.<sup>4</sup> Inasmuch as this translation is accomplished without the fish's seeing what it is doing to its own skin, we must at least conclude that somehow the perspective relations are so thoroughly "in" the space which the fish sees around it that they can *cause* other perspective relations just as truly as one chemical relation causes another. And just as one chemical relation causes another, without the assistance of any psychical act, so too with perspective relations: they are not set up by the "association of ideas," nor by an "*a priori* synthesis." They are physical, no less than weight is, and absolutely non-mental in the sense that they are not *constituted* by any psychical process.

The full interpretation of this particular matter can not here be given, for I must dwell upon the other significant discovery, namely, that the flatfish adapts its skin pattern only to the sea-bottom, in normal life, and only to a somewhat larger fraction of its own visual field, under the abnormal test conditions of Sumner's laboratory tanks. The animal notices objects above the bottom and even directly overhead; it follows such with its eyes and moves toward or away from them. *But the very same pattern which sets up the pigment reactions when it is underneath the fish has absolutely no effect when above it.*

A plate of opaque white glass, of the same size as the bottom of the tank, was covered with small, irregular blotches of black paint. . . . The three specimens used in this experiment had all been unmistakably influenced by this spotted plate when this was placed *beneath* them, assuming a much blotched appearance.

<sup>4</sup> Sumner has found that the plane in which a given surface lies with relation to the flatfish sometimes determines whether or not it shall be effective in calling forth a given change. It is not certain, he adds, that this influence is decided by "purely quantitative relations within the visual field." Should later experiments fully confirm the non-quantitative character of it, I think we should have to admit what I advanced in one of my previous papers on "Paradoxes of Visual Space"; namely, that *directions* are precisely as objective as extensity is.

. . . Upon the removal of the plate from beneath them, they had returned to a nearly unspotted condition. The spotted plate . . . was next inserted above the fishes (under the surface of the water, of course). The plate . . . was brightly lighted by the mirror below. That the fishes could see this spotted surface can not be doubted. Nevertheless, *not one of the specimens showed any appreciable influence, even after several days.*<sup>5</sup> Return of the spotted plate to the bottom of the tank, beneath the fishes, resulted in each case in a resumption of the blotched condition within a few hours at most.

Is there any other inference than that the perceiving function is not constructive or transformative, but merely selective? Certain *important* elements in the environment are attended to, to the exclusion of others, when and only when it is a question of adopting the skin pattern. The other elements are seen, but they are ignored for this particular reaction. Unquestionably, the flatfish has a genuine "field of attention" wholly distinct from the visual field. But the items entering into the field of attention are *not* transformed therewith; for they all pass over unchanged into the skin of the fish. I see no escape from the conclusion that the primary function of the psychic is to select, reject, and direct certain environmental characters with reference to certain *other* functions (such as nutrition, protection, locomotion, etc.). It seems equally sure that selection and reaction to the selected character does not necessarily alter the latter. In other words, adaptation of agent to environment does not have to involve a qualitative change in more than one of the two *relata*. And, in the special case of selective attention, this operation does not modify the essential characters of the stimuli selected for response.

In closing, I should like to suggest that the remarkable facts Sumner has brought to light may not raise the difficulties which their discoverer fears. I do not find it difficult "to conceive of a nervous mechanism competent to bring about such changes." Is it not quite probable that we have to do here with *an exceedingly simple*, rather than a mysteriously complex, structure and function? Instead of being an elaborate photochemical process which begins in the retina and undergoes a large number of incomprehensible transformations on the tract to the pigment cells, may the patterning not be effected by the direct conduction of untransformed ether waves to the chromatophores? To-day this hypothesis is not so extravagant as it was before Sherrington and others demonstrated experimentally that the periodicity of nervous impulses corresponds to the periodicity of serially repeated stimuli, at least up to rates of 500 per second. If we suppose that this correspondence holds for *all* cases, even those of ether wave shocks, we then have a nerve impulse

<sup>5</sup> Italics mine.

at the pigment cells which is, in pattern (if not in kind), identical with the stimulus pattern.

WALTER B. PITKIN.

COLUMBIA UNIVERSITY.

## VICARIOUS FUNCTIONING OF IRRELEVANT IMAGERY

OBSERVERS have frequently reported the inability to detect imagery of any kind whatever in the feeling of relation or in the consciousness of intention or purpose. On the basis of these introspections Woodworth<sup>1</sup> has suggested the possibility of special non-sensory centers in the association areas, which underlie the feeling of relation. Whether this cortical basis be conceived as the activity of a special organ or as a more or less definite neural set, the consciousness which goes with it is described as a "naked thought," an imageless consciousness. Such a description has been accepted by several other observers.

It is possible that the failure to detect sensory elements in these moments is due to the fact that the observer is looking for *relevant* material, usually of an imagery sort, which would, if discovered, relate more or less directly to the end processes between which the relation is objectively or socially felt to exist. Irrelevant imagery easily escapes report, as do present perseverative or sensory impressions which might easily enough be carrying the thought forward.

The writer's own introspection, in attempts to test the matter, has usually resulted in the observation of thoughts which seem to stand midway between the conventionally costumed idea and the nude relational processes which flowed through the consciousness of Woodworth's observers—thoughts, that is, which possess no decent apparel of their own, but which nevertheless make effective headway in foreign garments appropriated or borrowed to suit the occasion. Images and perseverative impressions, even immediate sensory processes from quite irrelevant sources, may often be seen to function vicariously as the end processes of a relation which is focal.

The writer's observations cover three clear degrees or stages of this vicarious activity. The first includes dream states in which images quite irrelevant as to source or quality may be seen to play a symbolic or metaphorical rôle in the play of meanings, relations, and complications of situation which make up the plot of the dream.

<sup>1</sup>"The Consciousness of Relation," in "Essays in Honor of William James," 1908, p. 491; and "The Cause of a Voluntary Movement," in the "Garmen Memorial Volume," 1906, p. 351.